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# Wind erosion risk in the southwest of Buenos Aires Province, Argentina, and its relationship to the productivity index

Juan C. Silenzi *, Nora E. Echeverría, Adrián G. Vallejos, Mariana E. Bouza, Martín P. De Lucia

*Department of Agronomy, National University of South (UNS), 8000 Bahía Blanca, Argentina*

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ABSTRACT

Wind erosion risk (WER) for soils of each municipality in the southwest (SW) of Buenos Aires Province (10,491,172 ha) was determined using the wind erosion equation (WEQ) model. WER results from multiplying the soil erodibility index ("*I*") of the soil by the climatic factor (*C*).

WER (Mg ha$^{-1}$ year$^{-1}$) of each municipality was: Bahía Blanca: 22.4, Coronel Dorrego: 18.6, Coronel Pringles: 4.5, Coronel Rosales: 48.2, Coronel Suárez: 4.5, Guaminí: 3.0, Patagones: 104.6, Puan: 12.2, Saavedra: 3.0, Tornquist: 6.8, and Villarino: 31.7.

The maximum weighted average of "*I*" (Mg ha$^{-1}$ year$^{-1}$) corresponded to Coronel Rosales (87.6), Patagones (87.2), Villarino (85.7), Puan (67.9); Guaminí (59.6), Coronel Dorrego (53.1), and Bahía Blanca (39.3); the remaining municipalities ranged between 34.9 and 32.1 Mg ha$^{-1}$ year$^{-1}$. The highest *C* (%) corresponded to Patagones (120), Bahía Blanca (57), Coronel Rosales (55), Villarino (37), Coronel Dorrego (35), Tornquist (21), and Puan (18); for the remaining municipalities it was 14%.

The productivity index (PI) is known to establish a numerical value of the productive capacity of lands. The relationship between WER and PI, weighted averages, in all the studied municipalities was fitted by means of a linear model, WER (Mg ha$^{-1}$ year$^{-1}$) = 95.23 – 2.09 $*$ PI (%) ($R^2$ = 66%), and a second-order polynomial model, WER (Mg ha$^{-1}$ year$^{-1}$) = 139.41 – 5.86 $*$ PI (%) + 0.07 $*$ PI$^2$ (%) ($R^2$ = 74%). No statistically significant relationship was found between WER and PI for each municipality.



## 1. Introduction

Wind erosion occurs in several parts of the world (Lal, 1990) where climate is characterized by scarce and variable rainfall, a high frequency of draughts, high temperatures and evaporation rates and high wind speeds (Woodruff and Lyles, 1967). Argentina has 220 million ha subject to semi-arid and arid climates (Fryrear, 1990), from which approximately 30 million ha are affected by wind erosion (PROSA, 1988). The SW of Buenos Aires Province occupies part of the arid and semi-arid regions in Argentina (Fig. 1a). Records show that in the SW of Buenos Aires Province there are more than 10 erosive storms per year, with wind speeds greater than 80 km/h, lasting for 2–3 days and with field-measured soil losses above 22 t per ha per storm (Bouza et al., 2009, 2010).

Wind erosion degrades soils irreversibly (Buschiazzo and Taylor, 1993; Zobeck and Fryrear, 1986), alters humification, reduces the organic matter accumulation rate (Buschiazzo et al., 2001, 2004) and, consequently, decreases chemical fertility (Lyles and Tatarko, 1986).

The economy in the SW of Buenos Aires Province is largely based on wheat production. Official records indicate that wheat quantities harvested during a five-year period (2002–2006) was 13 million t, which represents 32% of the total of this province. Losing 1 cm of soil in the SW of Buenos Aires Province reduces harvested wheat yields by 50 kg per ha on average (Silenzi et al., 1994). It is also known that, from the 3161,403 ha used for cultivating wheat, 639,717 ha show an annual soil loss of approximately 10 cm. Consequently, annual reduction in wheat yields averages 320,000 t, which represents 51 million United States dollars (Silenzi et al., 2009).

In order to address this situation, it is absolutely necessary to apply policies and transfer technologies capable of stopping soil loss caused by wind in rural areas. Land use and management must be planned for each particular area. Farmers must be made aware of the fact that erosion reduces production and their properties' price (McCormack, 1984).

Researchers' first role – and perhaps the most important one – is to adequately assess the productive potential of the soil resource and to provide guidelines for sustainable management. The value of the soil resource and the possibilities and limitations of

* Corresponding author. Address: Soil Conservation Unit, Department of Agronomy, National University of South (UNS), 8000 Bahía Blanca, Argentina. Tel.: +54 291 4595126.

*E-mail addresses:* jsilenzi@uns.edu.ar (J.C. Silenzi), echeverr@criba.edu.ar (N.E. Echeverría).

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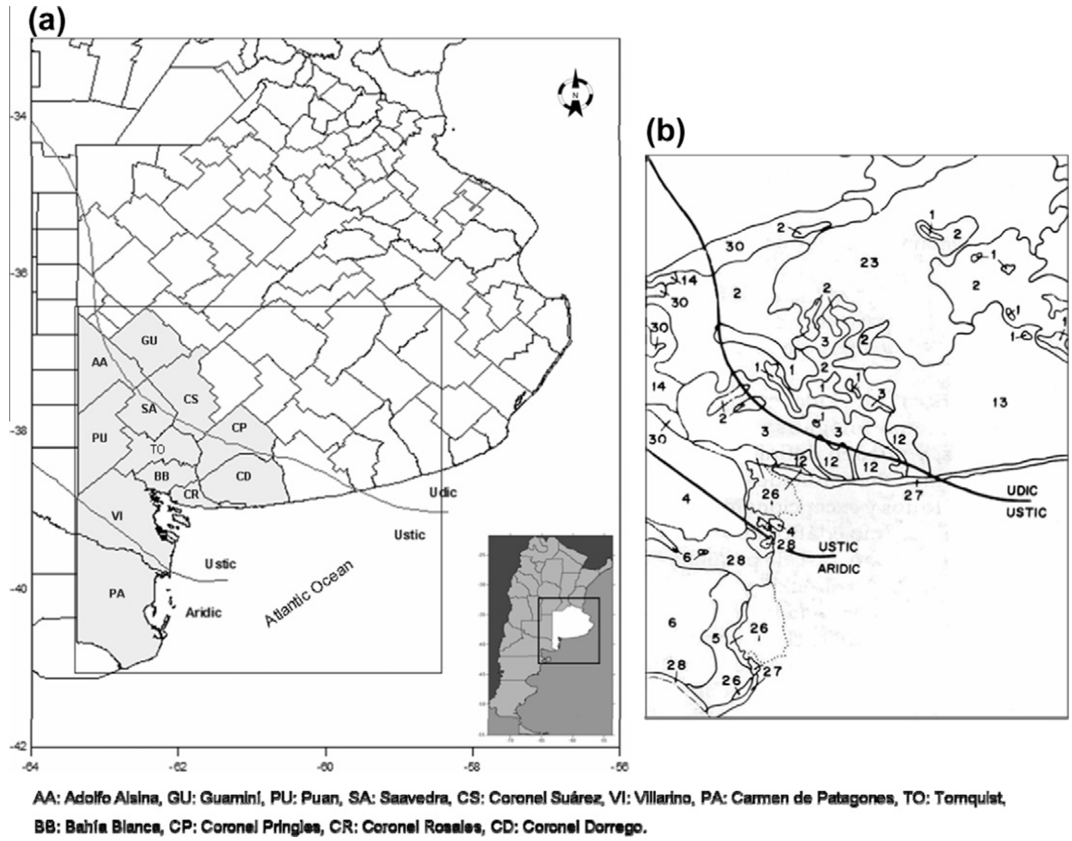


**Fig. 1.** (a) Municipalities in the SW of Buenos Aires Province, Argentina; (b) Soil moisture regime and cartographic units (INTA, 1989).

agricultural areas must be fully appreciated based on the best scientific knowledge available. Even though it not possible for soil scientists to solve social and economic problems in these areas, governments cannot approach them appropriately without accurate information provided by researchers (Stewart et al., 1991).

Erosion prediction has been a widely-used tool for directing soil conservation plans (Elliot et al., 1991). According to the Food and Agriculture Organization (FAO) (1980), potential wind erosion risk may be assessed by the wind erosion equation (WEQ). The WEQ developed by Woodruff and Siddoway (1965) and later improved versions indicate that soil loss is a function of a series of parameters, among which the soil erodibility index ("*I*") is key. "*I*" is the maximum erosion that a soil may suffer from and is determined by means of the erodible fraction (EF). EF is the percentage of soil aggregates smaller than 0.84 mm in diameter corresponding to a sample obtained from the first 25 mm of soil which is determined using a rotary sieve (Chepil, 1962). Fryrear et al. (1994) proposed using a multiple regression equation to calculate EF when a rotary sieve is not available. This equation has been tested for soils in the SW of Buenos Aires Province (Silenzi et al., 2009) and for other soils in Argentina (Hevia et al., 2007; López et al., 2007; Colazo and Buschiazzo, 2010).

Several land classification systems have been created to interpret soil quality based on a soil map (Sys et al., 1991). There are various methodologies for evaluating soil quality and determining adequate use and management of lands. One of these is the land capability classification (Klingebiel and Montgomery, 1961), which has been employed in Argentina on different scales. Despite being well designed, FAO's methodologies (1976; 1985a; 1985b) are not used as often as that provided by the United States Department of Agriculture (USDA). Another system adopted in Argentina is the productivity index (PI), which performs a quantitative analysis of the factors having a stronger influence on land productivity. These factors are included in an equation which gives the PI of each soil taxonomic unit (Riquier et al., 1970 cited by INTA, 1989).

The study of soil quality in a dynamic agroecological environment leads to considering several aspects of soil (Doran and Parkin, 1994; Bezdicek et al., 1996). Soil quality is defined taking into account its intrinsic properties as well as its productive and environmental buffering capacity (Harris and Bezdicek, 1994; Seybold et al., 1999). Within this framework, taking the first steps to obtain a soil quality indicator for aeolian environments is proposed. This indicator uses two environmental attributes of sustainability: productivity and wind erosion risk (WER). Productivity is quantified based on PI and WER is quantified based on the interaction between EF and climate aggressiveness (C). In this way, the possible relation between PI and WER is initially studied.

## 2. Materials and methods

The study was carried in the SW of Buenos Aires Province, specifically in Bahía Blanca, Coronel Dorrego, Coronel Pringles, Coronel Rosales, Coronel Suárez, Guaminí, Patagones, Puan, Saavedra, Tornquist and Villarino municipalities (Fig. 1a).

The soil moisture regime varies from udic to ustic and from ustic to aridic (Fig. 1b). Annual precipitation ranges from 850 to 350 mm. In this work, Guaminí is considered representative of the udic to ustic transition, Bahía Blanca is regarded as the centre of the ustic regime, and Patagones represents the aridic one.

Climate in Guaminí is sub-humid. Its average annual precipitation is 774 mm and evapotranspiration (ETP) is 745 mm year$^{-1}$, with a slight deficit in December and February and a large deficit in January. Its average annual temperature is 14.3 °C.

Bahía Blanca's climate is semi-arid. Its average annual precipitation is 650 mm and ETP is 760 mm year$^{-1}$. Water balance in soil